UNIVERSITAS KRISTEN INDONESIA
Fakultas Teknik

SURAT TUGAS

No. 36-B/UKI.F6.D/PP.2/2021

FAKULTAS TEKNIK UNIVERSITAS KRISTEN INDONESIA
TENTANG
TUGAS MELAKUKAN KEGIATAN PENELITIAN

Dalam rangka menyelenggarakan kegiatan Penelitian di Fakultas Teknik Universitas Kristen Indonesia, Jakarta maka dengan ini Pimpinan Fakultas :

Nama	: Ir. Galuh Widati,MSc.
NIP/NIDN	: 03.261261.03
Pangkat/Golongan	: Lektor/IVA
Jabatan Fungsional	: Dekan
Unit Kerja	: Fakultas Teknik UKI

Berdasarkan Surat Keputusan Rektor Universitas Kristen Indonesia Nomor : 93/UKI.R/SK/SDM.8/2018 tentang pengangkatan Ir. Galuh Widati,MSc. Sebagai Dekan Fakultas Teknik Universitas Kristen Indonesia masa kerja 2018-2022 menugaskan:

Nama	: Ir. Rahmad Samosir M.T
NIDN	: 111808/ 001065701
Pangkat/Golongan /Ruang	: Lektor
Unit Kerja	: Fakultas Teknik UKI

Untuk melakukan Penelitian dengan judul :

- Analysis of the use of biogas fuel from palm oil waste as a gas engine (electrical generator)

Semester Genap Tahun Akademik 2020/2021

Demikian Surat Tugas ini kami buat untuk dilaksanakan dengan penuh tanggung jawab.

Jakarta,01 Februari 2021

Dekan,

Ir. Galuh Widati,MSc.

Analysis of the use of biogas fuel from palm oil waste as a gas engine (electrical generator)

Cite as: AIP Conference Proceedings **2342**, 070004 (2021); https://doi.org/10.1063/5.0045876
Published Online: 22 April 2021

Rahmad Samosir, Budiarto, and Andreas Kristiawan

Analysis of The Use of Biogas Fuel from Palm Oil Waste as a Gas Engine (Electrical Generator)

Rahmad Samosir[a)], Budiarto, and Andreas Kristiawan

Mechanical Engineering Study Program, Faculty of Engineering, Universitas Kristen Indonesia, Jakarta Jl.Mayjen Sutoyo no.2 Cawang East Jakarta 13630

[a)]Corresponding author: rachmadsamosir@yahoo.com

Abstract.An analysis of the use of biogas fuel from palm oil waste has been carried out o produce mechanical energy, including moving generators that produce electricity. In this study two different types of gas are used, namely natural gas and biogas obtained from palm oil waste. This test aims to analyze what the impact of each gas on the performance of the gas engine both in terms of electricity output, fuel consumption and efficiency level. The low calorific value of natural gvvas is 9424 kKal / Nm ^{3} (39,458 kJ / Nm^3 and from the test results the power generated is 10.169 kWh / Nm3 while for biogas the power is 6.062 kWh / Nm^3, then the low heating value of biogas is 10.169 kWh / Nm3 while for biogas the power is 6.062 kWh / Nm^3, then the low heating value of biogas is obtained. 5615 kJ / Nm^3 40.32% lower than the low heating value (LHV) of natural gas. From the results of the analysis it was concluded that the biogas from palm oil waste fulfills the requirements as engine fuel.

INTRODUCTION

Gas engine is one of the engines that functions to produce power that can also drive an electric generator. Along with the changing times, the human need for electricity continues to increase. One source of electricity comes from a gas generator. The way this generator works is to convert chemical energy into heat energy, from heat energy converted into mechanical energy then from mechanical energy in the form of rotation to electricity. This engine fuel is in the form of gas. The biggest source at this time is natural gas originating from inside the earth or commonly referred to as natural gas.

In addition there are several other sources of gas obtained from the process of micro-organisms organic materials that we commonly call biogas, including those obtained from palm oil liquid waste or POME (Palm oil Mill Efluent).

The composition between the two gases is different. Based on this background the authors conducted an analysis test with the title "Comparative Analysis of Performance of Engine Gas with Natural Gas Fuel and Biogas from Palm Oil Waste".

Biogas is formed naturally when palm oil liquid waste (POME) is decomposed under anaerobic conditions. Without control, biogas is a major contributor to global climate change. Biogas on average consists of 50 - 75% methane (CH_4), 25-45% carbon dioxide (CO_2), and a small amount of other gases. Biogas has a flame temperature of 650˚ - 750˚C. Biogas is odorless and colorless gas. Biogas volume is usually expressed in units of Normal cubic meters (Nm^3) and atmospheric pressure. Methane (CH_4), the main component of biogas can be combusted with additional oxygen, before it is distributed directly to the gas engine to produce torque (power), these gases will go through a scrubbing and dehumidifying process in advance whose function is to reduce H_2S levels which are corrosive and eliminating the moisture content so that it does not cause problems when the gas has entered the engine combustion chamber.

Literature Review

Erdiwansyah, University of Malaysia Pahang, Biodiesel Alternative Fuels Biodiesel is an alternative fuel that has a lot of availability. This fuel is used to replace fossil fuels. *Kari Lyn Lyng, Ostfold Research, Biogas as Alternative Fuel in Transportation* Biogas that has been upgraded is often referred to as biomethane used as fuel altrernative vehicles

The International Conference on Chemical Science and Technology (ICCST – 2020)
AIP Conf. Proc. 2342, 070004-1–070004-7; https://doi.org/10.1063/5.0045876
Published by AIP Publishing. 978-0-7354-4085-2/$30.00

such as trucks and buses, compared to natural gas, biogas is more environmentally friendly because it is a greenhouse gas that is utilized so it does not pollute the environment. *Hasoloan, University of Indonesia, Coconut Oil (CPO) as fuel for the Genset Engine* Palm oil (CPO) is one of the basic ingredients for making biodiesel fuel. The results showed the use of a mixture of CPO up to a concentration of 50% can be used directly as fuel without requiring heating with maximum performance on a 30% CPO mixture. *Irhan Febijanto, Agency for Assessment and Application of Technology Optimization of Metane Gas as an Energy Source in Coconut Oil Mill* One of the developments of PLTBg in palm oil is to sell electricity to PLN, because at present the regulations and buying tariffs from PLN are not good, so another use of methane energy that can be done is diverted as boiler fuel to replace the existing shells.

Engine Performance

There are various parameters in measuring the performance of a combustion engine, some of which are power, efficiency, and fuel consumption.

1) Power

Power is the amount of work of the motor of time unity. (Arends and Berenschot, 1980: 18). One unit of power is the hp (horse power). Power in four-wheeled vehicles can be measured using a dynamo meter, so to calculate the shaft power can be determined using equation (1).

$$P = \frac{2\ \pi\, n \mathrm{T}}{75x60} \qquad (1)$$

P = shaft power (hp) T = torque (Kgf.m)
n = engine speed (rpm)
1/75 = factor conversion unitKgf to hp
1/60 = conversion factor of rpm units to translational speed
(m/s) 1hp = 0.7355 kW and 1kW = 1.36 hp

2) Efficiency

Efficiency is the ratio between the energy input and the energy output generated by the engine. At the required input engine gas has been determined from the manufacturer in units of kW,

Eff = Energy input/Electrical output (2)

ff = Efficiency (%)
Energy input = Energy input (kW)
Energy output = Electrical output generated (kWe)

3) Specific Fuel Consumption

SFC is the amount of fuel per time to produce power of 1 HP. So fuel consumption is a measure of the economy of fuel use, with the equation below.

SFC = Power of input/LHC (3)

SFC = specific fuel consumption (Nm^3 / hp)
Pin = Input power (kW)
Low heating value of natural gas (LHV) = 9424 k Cal / Nm^3 [9] = 39,458 kJ / Nm^3

SFC can also be explained as a comparison between the fuel used as input energy and the power produced as output. The higher the SFC value means the more fuel energy that is not converted to power. This is because the fuel entering the cylinder is not completely burned, or there is a thermal and mechanical loss.

4) Gas Analyzer

Gas analyzer Is an instrument that serves to measure the proportion and composition of gases. The usual gases measured by this device are carbon dioxide (CO_2), oxygen (O_2), carbon monoxide (CO) and metane (CH_4). This gas analyzer is generally used and installed before the gas pipeline that goes to the gas train gas engine, from there the gas analyzer will send a signal of 4-20 Micro amperes to be read on the control panel of the gas engine, so that the gas engine will be able to automatically adjust the flow of gas 10% supplied additives.

5) Gas Flow Meter

Gas flow meter is a device used to measure the flow of gas that flows. This tool is mounted on the gas pipe before entering the gas engine

The gas flow meter will give a signal of 4-20 mA to the gas engine and then the signal is processed as one of the parameters to be automatically responded by the gas engine to regulate its combustion

F.AVL Methane Series 3.2 AVL Methane 3.2 is a counting application used by manufacturers. With this application, users can find out the value of heating value of the composition of the gas entered, which then the value of heating value will be used to determine the value of the Specific Fuel Consumption.

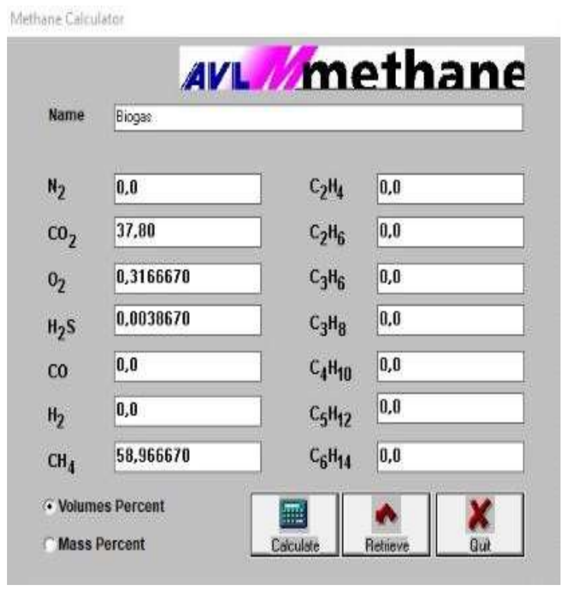

FIGURE 1. Example display on AVL Methane 3.2 showing what gas compositions can be filled (1)

RESEARCH METHODOLOGY

The study was conducted using two types of fuels namely natural gas and biogas from palm oil liquid waste and under three different engine load conditions. Figure 2 above is the flow of the research process.

1. The experiments carried out have 2 types of gas, each gas has a different composition of formers.
2. Perform the process of checking the gas content after going through the gas treatment with anylizer gas to find out the composition and ensure that H2S levels are at the standard for bias into the gas engine (less <200ppm).
3. Turn on the axuxiliary gas engine such as pumps and radiators before the engine starts operating, to ensure the engine oil and engine cooling are properly circulated.
4. Turn on the engine start button, load the engine gradually.
5. Perform power loading on the engine with load / load that has been determined for 100%, 75%, and 50%.

6. Take the data record of power & fuel consumption on the control panel that has been connected via a laptop or can also be via scada.
7. Repeat process 2 - 6 until all types of gas are tested, then do an analysis of each test result.

For the value of power and efficiency can be directly taken from the control panel but for the value of fuel consumption the Specific Fuel Consumption (SFC) calculation method is used, where from the AVL methane application the fuel consumption value and fuel consumption time can be taken, which can then be included in equation (3).

From the torque, power and SFC values of the two samples, an analysis of the physical properties of the lubricant is carried out, and an interesting relationship and effect on the performance of the engine gas. The following are the specifications of the palm oil liquid waste biogas.

TABLE 1. Biogas Gas Specifications from Palm Oil Liquid Waste

Component	Vol %
Oxygene (O_2)	0,31667 %
Nitrogene (N_2)	<1%
Methane (CH_4)	58,96667%
Carbon Dioxide (CO_2)	37,8%
Hirogen (H)	<1%

RESULTS AND DISCUSSION

From the results of tests of the two types of gas, here are the results and analysis.

Test Results

From the calculation of natural gas and biogas LHV, it is used to calculate engine gas performance including: fuel consumption, engine gas output and engine gas efficiency.

TABLE 3. Calculation Results for Natural Gas

	Natural Gas		
Load	100 %	75%	50%
Fuel Gas LHV (kW/Nm^3)	10,17	10,17	10,17
Energy Input (kW)	2608	2004	1414
Gas Volume Consumption (Nm^3)	256,5	197,1	139,1
Efficiency	40,9 %	39,80 %	37,40 %
Electrical output (kWe)	1066,7	797,6	528,8

From the calculation results in the table above, the engine fuel consumption using natural gas at 100% load conditions is 256.5 Nm^3, 75% loading is 197.1 Nm^3 and at 50% loading is 139.1 Nm^3. Judging from the efficiency because the input energy for each loading is different then the engine efficiency will also be different. At 100% loading the input energy required by the engine is 2608 KW with 40.9% efficiency, at 75% loading the required input energy is 2004 kW with 39.8% efficiency, and at 50% loading the required input energy is 1414 kW with efficiency of 37.4%. In terms of fuel consumption with LHV 10.169 kW / Nm^3 at each loading the lower the loading the less fuel consumption is needed, loading 100% requires 256.5 Nm3 fuel, 75% loading requires 197.1 Nm3, and at 50 loading % requires 139.1 Nm^3.

TABLE 4. Calculation results on Biogas

	Biogas		
Load	100 %	75%	50%
Fuel Gas LHV (kW/Nm^3)	6,062	6,062	6,062
Energy Input (kW)	2608	2004	1414
Gas Volume Consumption (Nm^3)	430,2	330,6	233,3
Efficiency	40,9 %	39,80 %	37,40 %
Electrical output (kWe)	1066,7	797,6	528,8

Judging from the efficiency because the input energy for each loading is different, the engine efficiency will also be different, at 100% loading the input energy required by the engine is 2608 KW with 40.9% efficiency, at 75% loading the required input energy is 2004 kW with 39 efficiency, 8%, and at 50% loading the required energy input is 1414 kW with an efficiency of 37.4%. In terms of fuel consumption with LHV 10.169 kW / Nm^3 at each loading the lower the loading the less the fuel consumption required, 100% loading requires 430.2 Nm^3 of fuel, 75% loading requires 330.6 Nm^3, and at 50% loading requires 233.3 Nm^3.

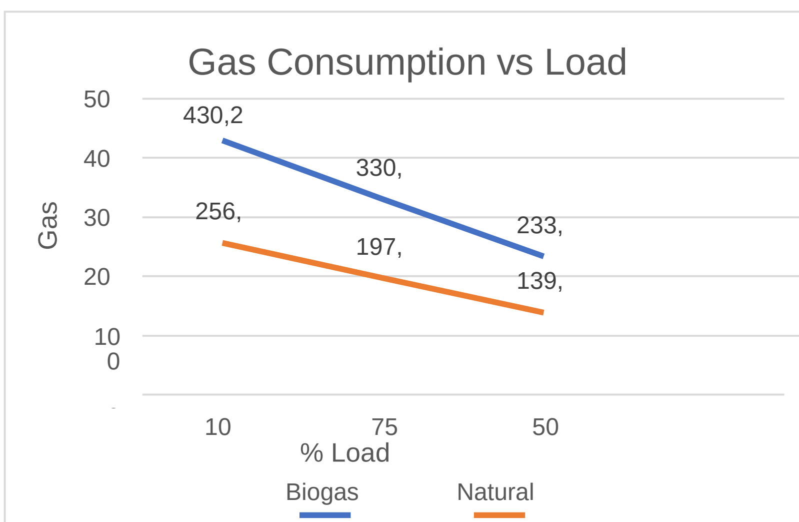

FIGURE 2. Comparison of Gas Consumption Graph between Load in Natural Gas and Biogas from Palm Oil Liquid Waste

From Figure 2, shows the comparison graph of cas consumption that there is a difference between the two contained in fuel consumption, because natural gas has a higher LHV than biogas, the fuel consumption will automatically be less. PAO samples are drawn in yellow, Organic Ester samples in purple, and PAG samples in green.

The resulting power graph produces a linear form where the increase in the value of power is directly proportional to the increase in RPM, if seen from equation (1), the value of power is directly proportional to the increase in RPM, until the power value reaches a maximum value at RPM 6200, after the power reaches a maximum value, the power will decreased, this can be seen in the graphic image (4).

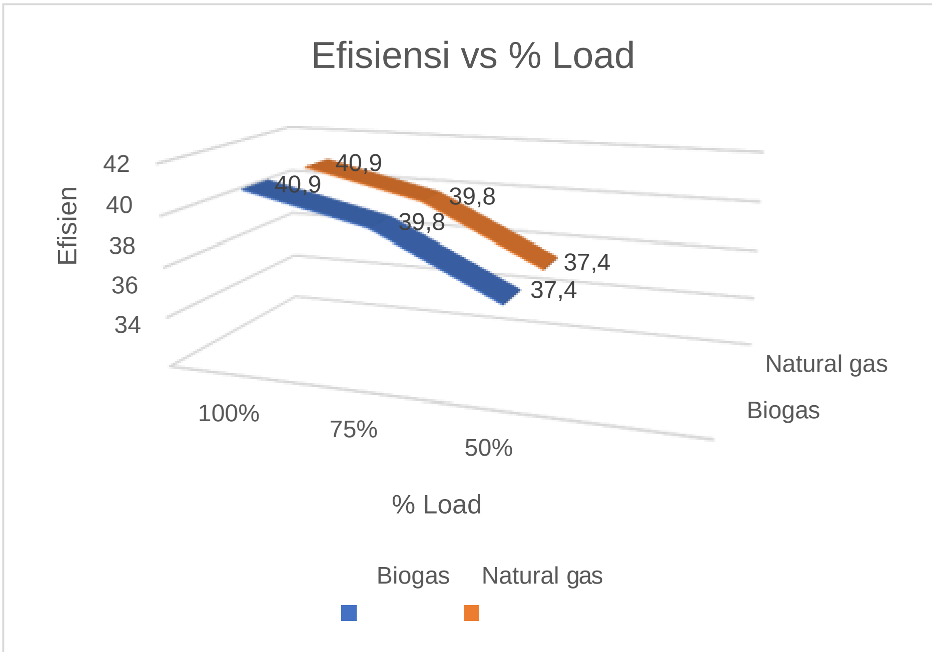

FIGURE 3. Comparison of Efficiency and Load Comparison of Natural Gas and Biogas from Palm Oil Liquid Waste

Based on the graph above the ratio of engine efficiency at each loading both using natural gas and biogas fuel is the same. This is because the input energy required by the engine in both is the same, and the output released by the engine has been set from the manufacturer is the same, can be explained by the RPM or engine speed that has been simulated at RPM 1500 using a device called a governor. The results will be different if the engine has a different RPM/speed, unlike a combustion motor where the speed depends on the fuel and there is no limitation at the speed see Figure 3.

CONCLUSION

From the results of research on the performance of the Jenbacher JGS 320 gas engine using natural gas fuel and biogas from palm oil liquid waste. The following conclusions are produced of the two fuels, natural gas fuels consume less fuel with a number of 256.5 Nm^3 with an LHV of 10.169 kW / Nm3. With the same engine output of 1067 KWe, fuel consumption for biogas is 430.2 Nm^3, with an LHV of 6.062 kW / Nm3. Biogas fuel from palm oil liquid waste is able to be used for fuel gas engines, although more volume is needed.

REFERENCES

1. GENERAL ELECTRIC, *Technical Description of JGS 320 GS BL* (2017).
2. Suyanto, *Gasoline Motorcycle Theory*, BSE Vocational School. (1989).
3. Ministry of Education National. *Engine Test Overview*. University of Sussex. (2003).
4. Ministry of Energy and Mineral Resources of the Republic of Indonesia, *Energy and ESDM*

Information Book for People's Welfare (2015).

5. Siregar P. *Biogas Production Through Utilization of Palm Oil Mill Liquid Waste Plant with Anaerobic Digester*, Thesis of Universitas Sumatera Utara. (2009).
6. Sitorus T B. *Overview of developing natural gas as an alternative fuel*. Department of Mechanical Engineering, Faculty of Engineering, University of North Sumatra, digitized by USU digital library (2002).
7. Irvan Trisakti B, Tomiuchi Y, Harahap U, Daimon H, IOP Conf. Series: Mater.NSci Eng. 206012094 (2017).
8. Jenbacher JGS 320 GS BL Manual Book of Generator Set (2017).
9. Forster - Carneiro, Perez M. Focusing on The Inoculums Sources, Biorec Techno **198**: 3195-3203 (2007).
10. Directorate General of Oil and Gas, Ministry of Energy and Mineral Resources